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A Modeling System for Integral Simulation of Propagation of Ocean Surge and Wave and Their Impinging on Coastal Structure (Extended Abstract)

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A Modeling System for Integral Simulation of Propagation of Ocean Surge and Wave and Their Impinging on Coastal Structure

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1. Introduction

Now it has become necessary to develop our capability to directly simulate many emerging coastal ocean flow and wave problems. An example for such problems is the 2011 Tohoku Tsunami, which started as surface waves with small amplitude in a deep ocean with a horizontal scale at O (100) km, evolved into huge walls of water as high as 39 m near seashore, and then became floods and damaged houses, bridges, etc. at O (10) m on lands. There are many more examples, such as flows at tidal power facilities and submarines. These flow problems present a common challenge to our modeling capability; they involve multiphysics phenomena spanning a vast range of spatial and temporal scales, however, so far essentially we have no methods and computer software to directly and integrally simulate these phenomena. Now it has become necessary for us to develop new capability to model them in efficient ways and high-fidelity. Towards this goal, we have developed a brand new, unprecedented modeling system that is able to directly evaluate many emerging multiscale, multiphysics flow problems. In this presentation, the newly developed modeling system will be introduced, together with numerical experiments and applications.

2. The SIFUM-FVCOM system The modeling system is hybrid of a solver for incompressible flow on unstructured mesh (SIFUM) and a finite volume coastal ocean model (FVCOM) [1,2,3]. In this system, the former resolves local, fully 3D flows, and the latter captures the large-scale background flows. The hybrid system couples SIFUM and FVCOM in two-way and via overset grids, and it permits seamless transition of solution between them. As the first of its kind, it is able to simulate many multiple phenomena at distinct scales that cannot be handled before. The SIFUM-FVCOM system performs as intended in numerical experiments with regard to capturing physical phenomena and solution accuracy, and its results compare well with analytical, computational, and experimental data of typical flow problems [3].

3. Examples of Test and Application Fig. 1 depicts a flow in laboratory flume, in which wave is generated at the entrance on the left, and it propagates to the right and then climbs the beach and impacts a cylinder. The SIFUM-FVCOM system is applied to simulate the whole process of the flow, with SIFUM capturing the flow around the cylinder and FVCOM resolving the flow in the channel and on the beach. The simulated result is shown in the figure, and it is seen that the simulation compares well with experimental data on the hydrodynamic load.

Fig. 2 shows an application of the modeling system to a mimic coastal flooding problem in the New York region. In this problem, a tsunami-like wave is imposed at the open sea, and it propagates towards seashore and then generates a flood and impacts a coastal house. The realistic coastline, bathymetry, tides, etc. are adopted in the modeling. The model simulates the motion of the wave from its generation all the way to its impinging on the

house, and presents a direct estimate of hydrodynamic force on the house. Such simulation is beyond the reach of other existing models.

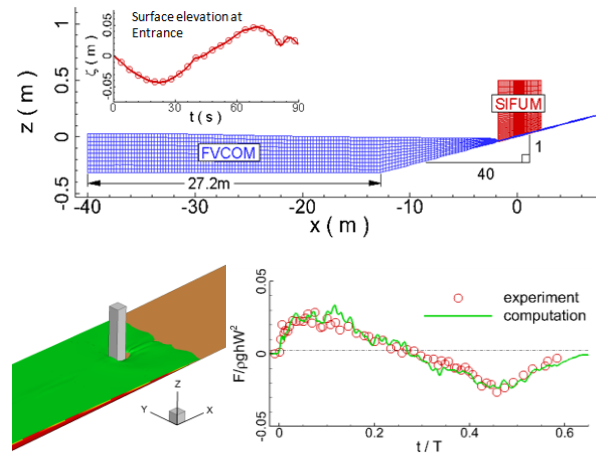


Figure 1. Simulation of surface wave and its load on a cylinder on beach. Top – model setup and meshes. Left bottom – simulated surge on beach. Right bottom – comparison of computed and experimental loads on the cylinder.

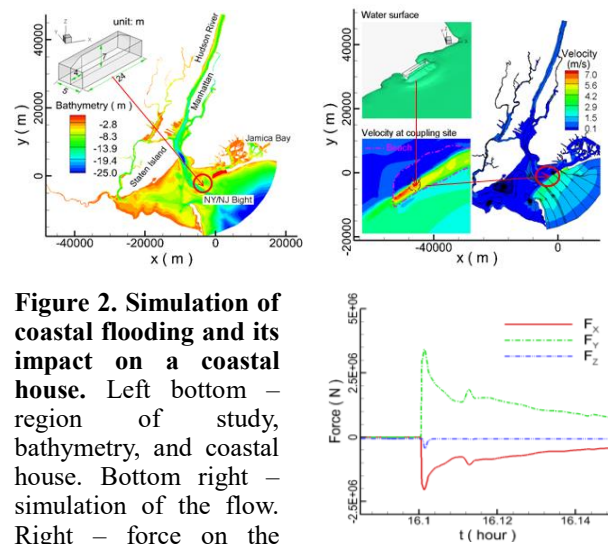


Figure 2. Simulation of coastal flooding and its impact on a coastal house. Left bottom – region of study, bathymetry, and coastal house. Bottom right – simulation of the flow. Right – force on the house.

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5. References

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